Priorities in Space Science

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We now face a traditional problem in astronomy. In a time with a shortage of funds relative to plans, there must be a competition for those funds. That's the way we do it, the free enterprise system at work, maybe you call it social Darwinism, the survival of the toughest and the noisiest, or you might call it the right way to choose the very best to do the job. But who will speak for cooperation and shared facilities for the benefit of all? NASA as the funding agency for space astronomy must work with the community to establish a consensus. We have however faced many challenges recently and that consensus may be changing.

What are now called NASA flagship missions are actually the lifeblood of astronomy. NASA's Great Observatories (Hubble, Compton-GRO, Chandra, and Spitzer) have opened entire new fields and pushed back the frontiers beyond all imagination, observing radiation that does not reach the surface of the Earth. They have developed new technologies and they have supported generations of researchers. They are the main reason that NASA funds investigators to take observations and reduce the data and publish discoveries. NASA now has plans for a series of additional projects of comparable size: James Webb Space Telescope, Constellation-X, Space Interferometry Mission, Laser Interferometer Space Antenna, and eventually Terrestrial Planet Finders. They are all at risk because of current funding constraints in the NASA budget.

Many astronomers fought to stop the HST for decades while it was being built, and even after it was launched many claimed that they could do better on the ground, but now that we built it and serviced it with 4 shuttle flights, 2000 astronomers use it every year. It's the most productive scientific tool ever built. It's the shining example of the benefits of the manned space program, the best thing we've done since the Apollo, in my opinion. It's made astronomy front-page news worldwide. Every college can have an astronomy department with a professor who uses the Hubble. The Hubble observer grants have been one of the largest sources of support for university astronomy in history, at roughly $30 M/year for 15 years, and we hope for many more years. Hubble is the source of most of the good publicity that astronomy has gained over the last few years, and I think arguably the reason that astronomy is now a well-supported field. When Sean O'Keefe tried to turn HST off for safety reasons, astronomers and the general public rose up and told NASA that was a really bad idea even if the astronauts' lives are at risk, and the astronauts said they were willing to go.

Now we have the public statement of support for the very large project HST, and we have small research teams complaining as before that they don't like having to wait. I am a member of one such team now (the WISE, the Wide-field Infrared Survey Explorer), and I am a member of a team competing for a Discovery mission to hunt for new planets. I was one of those people complaining when I was the Project Scientist for the Cosmic Background Explorer (COBE) satellite, the one that showed the Big Bang is right by

proving the cosmic background radiation has a blackbody spectrum, that discovered that the early universe has density and temperature fluctuations, and that found that half the luminosity of the universe was in the infrared and completely unexpected by most astronomers. The COBE team had to wait for the IRAS mission, which was over budget and behind schedule, and it had to fight with the Hubble mission for the top Goddard engineers and the money to complete the COBE, and it had to be redesigned for a Delta launch after the Challenger explosion. But the IRAS opened up a new field of astronomy, the COBE opened up precision cosmology, and the Hubble opened up a generation of amazing discoveries as a public facility used by thousands of astronomers every year.

Remember that servicing the Hubble is not a sure thing. The Shuttle still isn't flying frequently, we still don't know if it will pass its safety requirements, though we are counting on the professionals to get the job done, and we don't know how long it will take to go back to service the Hubble. If we get there in time, the Hubble will have a long lease on life. But we might not.

So we planted the seed corn for its successor 10 years ago in the fall of 1995. Alan Dressler chaired a committee, NASA made a plan, the National Academy compared it with other small and large projects, and rated it #1. The JWST will have a wide range of capabilities to support all fields of astronomy, ranging from the first light in the universe, to the formation of galaxies, to the formation of stars and planetary systems, to the evolution of planetary systems and the origins of life. JWST provides imaging and spectroscopy and coronography over the range of wavelengths from 0.6 to 28 microns, most of which can not be studied from the ground, and it overlaps the HST range down to 0.6 microns with far better sensitivity than HST can provide even there.

NASA started in on the project and invested in the needed technology. We planted the seed corn. Now we have the recipes for all the hard stuff, the detectors, the mirrors, the wavefront control, the deployment, the special integrated circuits to read out the detectors, and it's all working. We have cut the mirror blanks and we're starting to polish the first mirror segment. We have international agreements with ESA and CSA to provide the rocket, the near IR spectrograph, half the mid IR instrument, the fine guidance system, and the tunable filter imager. ESA and CSA together are committing $400 M to the project. We reached a stage of maturity where we do know the cost, and we've had truly independent cost estimates from organizations that are chartered to do that, and they agree we have the right cost. From here to launch will cost NASA about $2 B, and operations for 10 years will cost about $1 B, including grants to the observers and their students.

But NASA astronomy has been hit hard by outside forces. The Columbia accident has stretched out the Hubble servicing. Other government agencies resisted the Ariane launch vehicle for JWST. We're fighting a war in Iraq. Hurricane Katrina devastated Louisiana. Billions of dollars have been taken out of space science to pay for the manned space flight program, and some of that you didn't even see, because it was hidden by NASA's switch to full cost accounting.

Now JWST's schedule has been stretched way out. Our budget for FY06 is less than it was in FY05, and we had to fire people, ranging from science team postdocs to senior engineers. That wasn't enough to meet all the other claims on the budget from other projects. But we kept our seed corn growing, we kept on with the technology demonstrations, and that's almost complete to NASA's TRL (technical readiness level) 6.

Some people think and say that the program balance problems are because of JWST's cost growth. But that's not close to the whole story. JWST's cost growth has been budgeted at the end of the project by stretching the project out to 2013. That's caused the cost to go up too, because delay is expensive. But the NASA budget problems in the near term do not come from the cost growth of JWST, they come mostly from a) the loss of funds from space science to help fix the Space Shuttle, b) taking HST servicing out of the budget, and then c) putting it back in, without raising the budget to go with it. The world community pressed for HST and they clearly won. But they may not have appreciated that we're in a zero-sum game, that the cost could continue to grow because of Shuttle delays, and they weren't comparing options, they were pushing for the bird in the hand to be kept alive. But the bird in the hand has turned out to be expensive too.

I think the JWST is essential to the long-term health of the space astronomy program. It is the only candidate to replace Hubble as the workhorse space observatory for thousands of astronomers. Indeed by 2013 it could well be the only space observatory operating. The ones we've launched already will be old and possibly dead, even HST after a successful servicing mission. There are no small general-purpose observatories in the works. Excellent single-purpose missions like Kepler and SIM that are already in progress are not available for many astronomers, new Discovery and Explorer missions are (correctly) focused on single topics, and JDEM (the Joint Dark Energy Mission with NASA and DoE) would at best launch around 2016 if funding were started now. Flagship missions like SIM, Con-X, LISA, and SOFIA have budgets comparable in scale to JWST and require national and international consensus. Eventually, they will also support large numbers of researchers and their students. So if the community wants to have a coherent program with an observatory in space in 2013 and more to follow after it, they need to make sure it happens. The priorities established by the National Academy's Decadal Survey in 2000 are a good place to start.